

# **Whitepaper on using Large-Area Picosecond Photosensors for Neutrino Experiments**

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The next generation of long baseline neutrino experiments will use large volume detectors, which require instrumenting very large surfaces with photo sensors. Traditionally, photomultiplier-tubes (PMTs) have been used as light detectors useful in low intensity applications. The combination of high gain, low noise, high frequency response, and large area of collection has earned photomultipliers an essential place in nuclear and particle physics, astronomy and medical diagnostics. However, PMTs show limited time and spatial resolution as well as high cost thus limiting high detector coverage and in turn resulting in less optimized detection performance.

The LAPPD collaboration [1] has developed a planar detector module with 100 picosecond time resolution and one cm spatial resolution across the area of the module. The collaboration is in the process of commercializing these planar detector modules. Another new development in the field of the detector R&D is the development of cheap high light-yield water-based liquid scintillator [2]. Using both water Cherenkov radiation with scintillator light could enhance the detection of lower energy particles and particle identification at higher energies. A combination of LAPPD and water-based liquid scintillator detector may lead to applications that could result in game-changing experiments in the field. Potential applications of this technology to intensity frontier experiments could include: Hyper-Kamiokande, Lena, Daya Bay II and the recently proposed CHIPS detector in the NuMI beamline [3].

The development of reconstruction algorithms that can exploit the potential of this technology is underway. We have initially shown that for a given detector size, the uncertainties in the leading edge of the photon time of arrival distribution become smaller if larger photodetector coverage is considered. Thus combining better timing resolution with larger area coverage is key to the design a novel high-resolution large detector.

The technology of a novel high-resolution Large-Area Picosecond Photosensor-based Detector has the potential to significantly improve detection performance by increasing the detector coverage, granularity, timing resolution and quantum efficiency and/or reduce the cost of technology. Improved performance would translate into the benefits of a precise position and time resolution when particle interactions are detected, improving particle identification techniques and enhancing background rejection capabilities. The addition of a scintillation component can expand the capabilities of these detectors to low energy particles and further improvements to particle identification at high energies. The next generation of precision long baseline neutrino experiments must significantly increase both the total number of neutrinos interactions available as well as improve the information recorded of each interaction. We propose that the combination of technologies discussed in this whitepaper can achieve that.

- [1] <http://psec.uchicago.edu/> Large-Area Picosecond Photo-Detectors Project.
- [2] M. Yeh, et. al. “**A new water-based liquid scintillator and potential applications**”, *Nuclear Instruments and Methods in Physics Research A*, Volume 660, Issue 1, p. 51-56.
- [3] J. Thomas, et. al. “**CHerenkov detectors In mine PitS (CHIPS): A White Paper**” submitted as an Intensity Frontier White Paper.